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Influence of crude oil and detergents on the concentration of some ions in hemolymph of the shrimp Crangon crangon L. and the crab Rhithropanopeus harrisi Gould

Z. Zbytniewski, G. Drewa, F. Pautsch and T. Dabrowska

Department of Biology, Medical Academy, 80–211 Gdańsk, Poland

Abstract

Solutions of detergent or crude oil of 10 ppm, 50 ppm, and 100 ppm after 48–96 hours of exposure induce significant changes in the ionic composition of the hemolymph of the shrimp *Crangon crangon* and the crab *Rhithropanopeus harrisi*. The concentrations of sodium, calcium, and chloride ions decrease, whereas the concentration of potassium increases in both species exposed to both pollutants. – The magnesium ion concentration decreases in the hemolymph of the shrimp incubated in solutions of detergent and in the crab incubated in the water containing crude oil. – It is suggested that changes of the ionic composition of the hemolymph of the studied shrimps and crabs under influence of both pollutants are possibly brought about by alteration of cell membrane permeability and action on some enzyme activities.

Zusammenfassung

Einfluß von Rohöl und Detergentien auf die Konzentration einiger Ionen in der Hämolymphe der Garnele Crangon crangon L. und der Krabbe Rhithropanopeus harrisi Gould

Lösungen von Detergentien oder von Rohöl in Konzentrationen von 10, 50 und 100 ppm verursachen nach 48–96 Stunden Einwirkung deutliche Änderungen der ionalen Zusammensetzung der Hämolymphe der Garnele *Crangon crangon* und der Krabbe *Rhithropanopeus harrisi*. Beide Schadstoffe erniedrigen die Konzentration an Natrium-, Calcium- und Chloridionen bei beiden Arten, während die Kaliumkonzentration ansteigt. – Die Konzentration an Magnesiumionen sinkt in der Hämolymphe von *C. crangon* nach Einwirkung des Detergens, sie steigt in *R. harrisi* nach Hälterung in rohölhaltigem Wasser. – Möglicherweise werden die Ionenkonzentrationen in der Hämolymphe der Garnele und der Krabbe bei Gegenwart beider Schadstoffe dadurch modifiziert, daß sich die Permeabilität von Zellmembranen und die Aktivität einiger Enzyme ändert.

Detergents (surfactants) are composed of molecules which have both hydrophilic and hydrophobic properties. According to HIGGINS and BURNS (1975) the world annual production of detergents exceeds 9 000000 tons. After being used in industry or households these substances pour out to rivers and seas.

The main toxic substances in crude oil are aromatic and aliphatic hydrocarbons with different numbers of carbon atoms in chain and different degree of saturation.

Table 1

Concentration of ions in hemolymph of the shrimp *Crangon crangon* and of the crab *Rhithropanopeus harrisi* (meq/l) in control animals and in animals after 96 (or 48) hours of exposure to 100 ppm of detergent or 100 ppm of crude oil

	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-
Crangon crangon					
Conc. of the ion in control animals	318.0	7.8	29.8	22.6	271.0
Conc. of the ion in animals exposed to detergent	150.0	9.6	36.0	9.2	232.0
Change in the ion conc. expressed as the percentage of the control conc.	− 52.8	+ 23.0	+ 20.8	− 59.3	− 14.4
Conc. of the ion in animals exposed to crude oil	260.0	9.8	17.6	20.8*	140.0
Change in the ion conc. expressed as the percentage of the control conc.	− 18.2	+ 25.6	− 41.0	− 7.9	− 48.3
Rhithropanopeus harrisi					
Conc. of the ion in control animals	325.0	8.1	91.2	49.4	471.0
Conc. of the ion in animals exposed to detergent	235.0	10.4	96.0	56.7	268.0
Change in the ion conc. expressed as the percentage of the control conc.	− 27.6	+ 28.4	+ 5.3	+ 14.7	− 43.1
Conc. of the ion in animals exposed to crude oil	277.0**	10.4**	70.8**	6.5**	118.0**
Change in the ion conc. expressed as the percentage of the control conc.	− 14.8	+ 28.4	− 22.4	− 86.8	− 74.9

* = in 50 ppm of crude oil
** = after 48 hours of exposure

It has been found that both pollutants are toxic to aquatic animals and plants (GELDER-OTTWAY, 1976; MORROW, 1974; NELSON-SMITH, 1974; REICHENBACH-KLINKE, 1974; SWEDMARK et al., 1971; ZBYTNIEWSKI et al., 1975a, 1975b). The toxicity of these substances is possibly brought about by alteration of cell membrane permeability, especially in gills (SCHMID and MANN, 1971). This action should result in changes of the ion concentration in the blood of aquatic animals. Interaction of anionic detergents with positive amino groups in enzymatic or neutral proteins results in inhibition of many enzymes and conformational changes in the protein molecules (DREWA et al., 1977; MANWELL and BAKER, 1967; NOZAKI YASUHIKO, 1962). Therefore we have decided to investigate the influence of both these pollutants on the ion concentration in the hemolymph of the shrimp and of the crab under laboratory conditions.

Concentration of sodium ion (flame photometry), potassium ion (flame photometry), calcium ion (complexometry), magnesium ion (complexometry) and chloride ion (Schales method) were assayed in the hemolymph of the shrimp *Crangon crangon* and of the crab *Rhithropanopeus harrisi* incubated in the following conc. of detergent ''Solo'' (mixture of anionic and nonionic detergents, containing about 33% of the active substances) or crude oil: 10 ppm, 50 ppm, and 100 ppm. The estimations were carried out after 1, 12, 24, 48, and 96 hours of exposure of animals to the action of pollutants, added to brackish water from Bay of Gdańsk (7‰ of salinity). The results obtained after 48 or 96 hours of exposure to both pollutants are shown in Table 1.

The sodium ion conc. in the control shrimp was 318 meq/1, and in the control crab – 325 meq/l. The conc. of this ion decreased in both species incubated in both pollutants but the changes were greater in the hemolymph of the shrimp than in the crab. The sodium ion conc. correlates negatively with the conc. of the toxic substances and with the time of exposure to pollutants.

The potassium ion conc. in the control shrimp and the crab were 7.8 and 8.1 meq/l respectively. The conc. of this ion decreased in the hemolymph of both species under influence of both pollutants.

The conc. of calcium ion in the control animals were 29.8 meq/l (shrimp), and 91.2 meq/l (crab). In animals incubated in the solutions of detergent the calcium ion conc. increased to 36.0 meq/l in the shrimp and to 96.0 meq/l in the crab, whereas in the hemolymph of the Crustacea incubated in the water containing 100 ppm of crude oil a decrease of the calcium ion conc. to 17.6 meq/l and 70.8 meq/l was observed.

The magnesium ion conc. in control shrimp was 22.6 meq/l and in the crab – 49.4 meq/l. The detergent induced a significant decrease in the magnesium ion conc. in the shrimp (to 9.2 meq/l after 96 hours of exposure to 100 ppm) and an increase of conc. in the hemolymph of the crab (to 56.7 meq/l). In water containing crude oil a drastic decrease in the magnesium ion conc. in the crab has been found (from 49.4 meq/l to 6.5 meq/l after 48 hours of exposure to 100 ppm), but only a slight decrease of conc. in the hemolymph of the shrimp (from 22.6 meq/l to 20.8 meq/l after 96 hours of exposure to 50 ppm of crude oil).

The chloride ion in the hemolymph of the control shrimp was 271 meq/l, and in the crab – 471 meq/l. The conc. of this ion decreased in the hemolymph of both species in both pollutants, but the changes were greater in the hemolymph of the crab than in the shrimp. In the latter the value was 140 meq/l after 96 hours of exposure to 50 ppm of crude oil, in the crab – 118 meq/l after exposure to 100 ppm.

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